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ABSTRACT

The purpose of this study was to examine the effect that coding (black and white or color) has on the achievement of students categorized as field dependent (FD) and field independent (FI) learners and to determine if there was any interaction between these variables (field dependency and color) across both visually and verbally oriented tests measuring different educational objectives. The subjects were 119 students enrolled in a basic educational psychology course at The Pennsylvania State University. They were classified as FD, field neutral (FN), or FI based on their performance on the Group Embedded Figures Test (GEFT), and randomly assigned to two treatment groups. The subject content consisted of 2,000 word instructional booklet on the anatomy and functions of the human heart with 19 illustrations designed to illustrate content being presented verbally. The illustrations were in black and white for treatment group I, and in color for Treatment II. After interacting with their respective instructional treatments, each student received two visually oriented criterion tests and two verbally oriented tests. The results of the study indicate that the concept of field dependence/field independence is an important instructional variable in the teaching-learning process. Color coding was also found to be an effective instructional variable for maximizing the information processing acquisition level for field dependent learners on the types of criterion measures employing visually oriented tests used in this study. However, on verbally oriented tests, color coding was not found to be an effective instructional variable for maximizing the information processing acquisition levels across all levels of field dependence. Study data are reported in 4 tables and 11 references are listed. (BBM)

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Title:

Effect of Color Coding on Cognitive Style

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A considerable amount of research has dealt with the identification of individual differences among learners and how best to approach these differences in developing learning strategies and supporting materials has led to active experimentation and inquiry concerning the role of cognitive-style variables. The usefulness of cognitive style research depends on its potential to identify specific information processing differences between several types of students. Field dependence-independence has been examined more closely than other cognitive styles, no doubt because it describes characteristics which are so directly applicable to the learning process. Measures of field dependence such as the GEFT employed in this study are arguably tests of ability. In fact, the aspect of field dependence-independence that is tapped by the GEFT has been identified as cognitive restructuring ability. There is certainly a strong visual-spatial element in field dependence-independence (Witkin, 1977). For this reason researchers have attempted to design visual instruction according to the characteristics of field-dependent and independent learners, hoping to capitalize on strengths and compensate for weaknesses.

Witkin, et. al. (1977) and his associates have noted that certain individuals interact to superfluous cues in a visualized instructional environment while others are able to identify precisely the critical information contained in a complex visualized environment. These two orientations called field dependence (FD) and field independence (FI) represent two ends of a continuum. Field dependent individuals, when presented a visualized presentation tend not to modify the structure but accept and interact with it as it is presented. They tend to fuse all segments within the visual field and do not view or interact with the visual components discretely. Field independents tend to act upon a visual stimulus, analyzing it when it is organized and providing their own structure when it lacks organization.

The FD/FI cognitive style appears to be especially important in the design of visually related information. Although many studies have examined the effects of visual attributes on learning (Dwyer, 1978, 1987) few have studied the effects of varied visual attributes on specific cognitive learning styles. Research has shown that color coding helps learners organize or categorize information into useful patterns which enables the learners to interpret and adjust to their environment. Color coding may be considered a strategy which students enhance or sharpen essential message characteristics by providing structures for the storage of new information (Dwyer, 1978). Dwyer (1978), in an extensive review of research on the impact of color vs. black and white comparison, found "color versions were to be significantly more effective than the black and white versions in facilitating student achievement of specific educational objectives. These results seem to provide substantial evidence that colors, in fact, are a viable instructional variable" (p. 149). However, a qualification is noted in that color has to be used judiciously and the visuals need to be appropriate for the type of educational objective to be achieved.

It was hypothesized that color coded visuals (Color) would be more effective than black and white coded visuals (B&W) in enhancing the salient visual cues thereby making them more identifiable and instructional to field dependent learners. The color coding would attempt to compensate for the restructuring skills absent in field dependent learners and subsequently lead to deeper information processing and increased achievement. This hypothesis seems plausible since field dependent learners tend to be global in perception and would be most inclined to take advantage of the increased structure provided by the color coding.

However, do color enhanced diagrams also have any effect on retention on verbal tests? Previous studies have investigated the use of B&W and Color coded

illustrations to support use of color enhancement over black and white illustrations in answering questions of a verbal nature, i.e., terminology and comprehension (Dwyer, 1968, 1978, 1987). However, there is no research available which investigates the role of color on verbal style questions across the cognitive style known as field dependence (FD), field independence (FI). Additionally, it is not known whether coding (B&W and Color) and field dependence interact or whether color coding positively affects the deficiency of field dependent learners to organize and structure instructional content.

Specifically, the purpose of this study was to examine the effect that coding (B&W and Color) has on the achievement of students categorized as FD/FI learners and to determine if there was any interaction between these variables (field dependency and color) across both visual and verbal oriented tests measuring different educational objectives, namely to learn terminology and basic facts, to identify locations and/or positions, construct and/or understand relationships and to engage in problem solving activities. It was anticipated that the findings of the present study would provide teachers and designers of instructional software with techniques and aids to be used with students possessing different cognitive styles.

Procedures

One hundred nineteen students enrolled in a basic educational psychology course at The Pennsylvania State University participated in this study. Students were classified as field dependent, field neutral, or field independent as a result of their performance on the Group Embedded Figures Test (GEFT), (Witkin, 1971). Students were divided into the different levels based on their mean achievement level on the GEFT. The grand mean achievement by students on the GEFT was 13.08 with a standard deviation of 4.01. Students with one half standard deviation above the mean were considered to be field independent ($n = 43$, $x=17.0$, $SD = .81$); students located one half a standard deviation below were classified as field dependent ($n = 29$, $x= 7.33$, $SD = 2.11$). Students in the middle were classified as neutral FN ($n = 45$, $x=13.17$,$SD=1.49$) (Moore & Dwyer, 1991). Students in the three GEFT levels were randomly assigned to two treatment groups. The subject content for the study consisted of a 2,000 word instructional booklet on the anatomy and functions of the human heart. Each booklet contains 19 illustrations which were designed to illustrate the content being presented verbally. The illustrations in Treatment I, the black and white version, contained black and white coded line drawings which highlighted the information and processes being presented. Students in Treatment II received the same visuals as did students in Treatment I; however, several different colors were used to highlight the information and processes being discussed. The major independent variables in the study were the effect that B&W and Color coding of information had on the information processing strategies of students identified as possessing different levels of field dependence.

Dependent Measures

Each student, after interacting with their respective instructional treatments, received two visually oriented criterion tests. The drawing test required students to draw a representative diagram of the heart and place the number of listed parts ($n=20$) in their respective positions. The emphasis for this test was on the correct positioning of the verbal symbols with respect to one another and in respect to their concrete referents. The identification, a 20-item multiple choice test, required students to identify the numbered parts on a detailed drawing of a heart. The objective of this test was to measure the ability of the student to use visual cues to discriminate one structure of the heart from another and to associate specific parts of the heart with their proper names. K-R 21 reliability coefficients from the drawing and identification tests were .67 and .80 respectively.

Each student, after interacting with their respective instructional treatments, also received two verbally oriented criterion tests. The terminology test (K-R 21, .83) was a twenty-item multiple choice test which evaluated students' knowledge of facts and terminology and the comprehension test (K-R 21, .88) measured understanding of the internal processes occurring within the heart during the diastolic and systolic phases (Moore & Dwyer, 1991).

Results

A series of two-way analyses of variance were used to analyze the data. The independent variables of color enhancement and cognitive style were tested across each of the four dependent measures (drawing, identification terminology and comprehension tests). An analysis of variance conducted on the drawing test indicated that there was a significant difference in mean achievement for cognitive style (FD/FI), $F(2, 111) = 3.99$, $p < .05$.

Field independent students ($x = 16.42$) scored significantly higher on the drawing test than did field dependent students ($x = 12.93$) on both the B&W and Color coded treatments. Across all levels of cognitive style (field dependent, field neutral, field independent), students who received the color coded illustrations ($x = 17.35$) achieved significantly higher scores on the drawing tests than did students who received the B&W coded illustrations ($x = 12.24$). See Table 1 for mean scores.

On the identification test, field independent students ($x = 17.23$) achieved significantly higher than did field dependent students ($x = 14.41$), $F(2,111) = 4.51$, $p < .05$. No significant differences in achievement were found to exist on the identification test between students receiving the B&W and Color coded instructional treatments, $F(1, 111) = 3.83$, $p. > .05$. Although across all levels of cognitive style, the mean achievement scores of students on the identification who had received the Color coded treatment ($x = 16.76$) were significantly higher than those who received the (B&W) coded treatment ($x = 15.09$). See Table 2 for mean scores. When student scores across the drawing and identification tests were combined into a total test both cognitive style mean score (FD/FI), $F(2, 111), = 5.00$, $p. < .05$, and Color coding, $F(2, 111) = 24.48$, $p. < .05$ were significant.

On the terminology test field independent students ($x = 14.54$) scored significantly higher in achievement than field dependent students ($x = 11.24$), $F(2, 111) = 5.37$, $p. < .05$. In examining the differences across cognitive style levels, no significant differences in achievement were found on the terminology test between students receiving the B&W and Color coded treatments, $F(1, 111) = .65$, $p. > .05$ (Moore & Dwyer, 1991). An insignificant interaction was found to exist between cognitive style and color coding (B&W and Color), $F(2, 111) = .29$, $p. < .05$. See Table 3 for mean scores.

As noted earlier, analysis of student achievement on the comprehension test indicated that field independent students ($x) = 12.81$) scored significantly higher than field dependent students ($x = 10.66$), $F(1, 111) = 3.81$, $p. < .05$. However, no significant differences in achievement were found to exist on the comprehension test between students receiving the B&W and Color coded treatments (Moore & Dwyer, 1991). See Table 4 for mean scores.

On the total criterion test in which all four dependent measures were combined, a significant difference was found to exist among the three field dependence levels, $F(2, 111) = 6.29$, $p. < .05$, but significant differences were found to exist between the B&W and Color coded treatments, $F(1, 111) = 10.62$, $p. < .05$. No significant interaction was found to exist between treatment type and the three field dependence levels, $F(2, 111) = 2.06$, $p. > .05$.

Two secondary analyses were conducted to examine achievement differences occurring among the three field dependence levels when students received only the B&W or Color coded treatments. The one way ANOVA indicated that significant differences existed in favor of the field independence students on

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all tests; the drawing test, $F(2, 58) = 3.78$, $p. < .05$, the identification test, $F(2, 58) = 3.83$, $p. > .05$, the terminology, $F(2, 56) = 4.19$, $p. < .05$, and comprehension tests, $F(2, 56) = 6.81$, $p. < .05$, when they received the B&W coded instructional treatments; however, when making the similar comparison among students receiving only the Color coded treatments no significant differences were found to exist among FD/FI students on the four independent criterion measures [drawing test, $F(2, 57) = .60$, $p. > .05$; identification, $F(2, 57) = 1.07$, $p. > .05$, the terminology test, $F(2, 57) = 1.60$, $p. > .05$, and the comprehension test, $F(2, 57) = .98$, $p. > .05$].

Discussion

The results of the experimental study support that the contention that field independent and field dependent learners differ in the cognitive processes they use as well as in the effectiveness of these cognitive processes as measured on tests measuring different education objectives. In the present study, field-independent students scored significantly higher than did field dependent students on the drawing, identification, terminology and comprehension tests (Table 1-4). These results might have been expected since prior research (Moore & Bedient, 1986) have found that field independent learners tend to score higher on criterion measures which require the acquisition of information from visualized instruction and are used to assessing visually complemented instruction. This finding is also consistent with the previous reviews of the literature that have concluded that field independent learners exhibit an active, hypothesis-testing strategy towards learning, whereas field dependent learners tend to employ a more tentative or spectator approach to learning (Goodenough, 1976). Annis (1979), in a study investigating cognitive style on study technique, found that field dependent students did not score as well as field independent students in completing items of high structural importance even when the passage was well organized. The implication being that field dependent students, in addition to receiving a well organized passage, may need explicit structural support to insure that they identify and interact with the critical aspects of the information being presented.

In the present study, significant differences in achievement were found to exist between FD/FI learners on the drawing test. Apparently, the use of color coding of the visualization did not provide sufficient structuring of the critical information to alter the information processing level of field dependent learners on this learning task which required students to construct and/or position the parts of the heart in their appropriate context on the drawing. However, on the identification test no significant differences in achievement were found between FD/FI learners who had received the Color coded treatments. For the type of learning measured by the identification test, Color coding was instrumental in providing the level of learning structure which enabled the FD learners to achieve at a level similar to that achieved by the FI learners. Prior research supports the notion that field dependent learners benefit from the restructuring aspect of instructional strategies (i.e., B&W coding to Color coding), while FI learners are not impeded by imposed structures (Grieve & Davis, 1971; Slatterly &Telfer,1979).

As noted previously, students identified as field independent in this study also achieved significantly higher scores on the two verbally oriented criterion tests than did students identified as field dependents. It appears the field independent learners were able to identify the essential salient cues and impose a more meaningful structure on the perceptual field in relation to the content being presented. Field dependent learners interacted with identical visualized content; however, they only interacted with the visualized instruction (perceptual field) at a superficial level. An inspection of the means achieved on the terminology (Table 3) and comprehension tests (Table 4) by students in the different FD/FI levels indicated that just over 50 percent of the total content to be measured by each

criterion test was acquired as a result of the visual coding (B&W and Color) of the instructional content (Moore & Dwyer, 1991).

In analyzing the performance of students who received only B&W coded treatments, it was found that the field independent students achieved significantly greater scores than did the field dependent students on the four criterion tests: drawing, identification, terminology and comprehension. The single color coding strategy (B&W) was not sufficiently strong enough to alter the information processing strategies of the field dependence learners. However, it was expected that the Color coded visuals would make the relevant cues more obvious to the field dependent learners, thereby improving their achievement on the verbal tests. The insignificant results on all four criterion tests did support this contention. Apparently, the Color coded illustrations provided a sufficient structure for the field dependent learners to interact with and internalize at a level similar to that achieved by the field independents. Field independent learners who interacted with the color Coded illustrations may have felt that these illustrations adequately conveyed the intended information and did not utilize their special skills to process the information deeply. For example, the directions to the instructional unit indicated that the unit was designed to help them understand the functions of the human heart. Students, as they preceded through both instructional treatments, may have felt that they understood the content adequately. Performance on the criterion tests between the two groups might have changed significantly if the directions in the instructional booklet had indicated that they would not only have to understand the functions of the human heart but would also have to perform on a test measuring knowledge of terminology and the functions of the various parts of the heart during the diastolic and systolic phases. Possibly, specific directions relating to precise performance expectations would have stimulated the field independent learners to use their special skills to initiate deeper information processing which, in turn, would have led to increased information acquisition.

The results of this study indicate that the concept of field dependence/field independence is an important instructional variable in the teaching-learning process. Color coding was also found to be an effective instructional variable for maximizing the information processing acquisition level for field dependent learners on the types of criterion measures employing visually oriented tests used in this study. The significant interaction on the comprehension test between treatment and cognitive style (FD/FI) found in this study appears to be a spurious finding and needs to be replicated before credibility can be attached to its existence. However, on verbally oriented tests, color coding was not found to be an effective instructional variable for maximizing the information processing acquisition levels across all levels of field dependence.

Note: This paper is based upon a paper presented at the meeting of the International Literacy Association, Washington, DC., October, 1991.

Table 1 - Mean Scores - Drawing Test

Field Dependence		Color		Total
		Color	Black & White	
FI	Mean	17.8	14.50	16.42
	SD	2.57	3.45	3.36
	n	25	18	43
Neutral	Mean	16.96	11.68	14.38
	SD	2.76	3.86	4.24
	n	23	22	45
FD	Mean	17.10	10.74	12.93
	SD	3.28	5.46	5.66
	n	10	19	29
Total	Mean	17.35	12.24	14.77
	SD	2.75	4.54	4.54
	n	58	59	117

Table 2 - Mean Scores - Identification Test

Field Dependence		Color		Total
		Color	Black & White	
FI	Mean	17.32	17.11	17.23
	SD	2.87	2.22	2.59
	n	25	18	43
Neutral	Mean	16.70	14.50	15.62
	SD	3.61	3.64	3.75
	n	23	22	45
FD	Mean	15.50	13.84	14.41
	SD	3.75	4.99	4.60
	n	10	19	29
Total	Mean	16.56	15.09	15.92
	SD	3.34	3.98	3.76
	n	58	59	117

Table 3 - Mean Scores - Terminology Test

Field Dependence		Color: Color	Color: Black & White	Total
FI	Mean	14.48	14.61	14.54
	SD	4.33	3.68	4.03
	n	25	18	43
Neutral	Mean	13.22	12.05	12.64
	SD	3.78	4.08	3.92
	n	23	22	45
FD	Mean	11.80	10.95	11.24
	SD	4.42	4.06	4.13
	n	10	19	29
Total	Mean	13.52	12.48	12.99
	SD	4.18	4.16	4.18
	n	58	59	117

Table 4 - Mean Scores - Comprehension Test

Field Dependence		Color: Color	Color: Black & White	Total
FI	Mean	12.28	13.56	12.81
	SD	3.78	4.54	4.11
	n	25	18	43
Neutral	Mean	12.83	8.68	10.80
	SD	3.64	3.81	4.24
	n	23	22	45
FD	Mean	10.70	10.63	10.66
	SD	5.29	4.18	4.50
	n	10	19	29
Total	Mean	12.22	10.80	11.50
	SD	4.01	4.56	4.34
	n	58	59	117

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